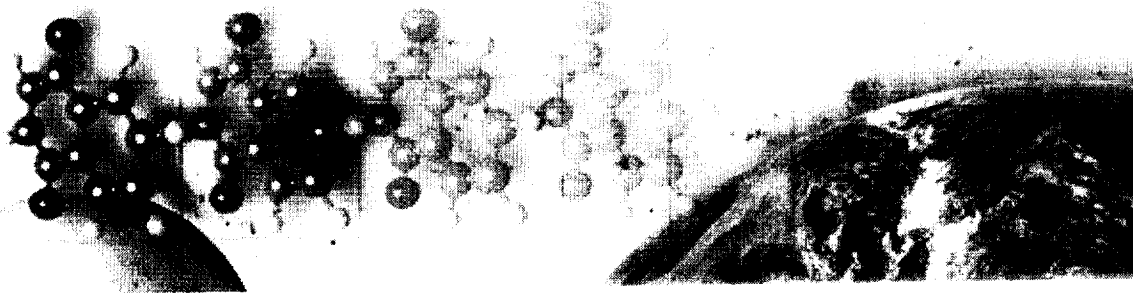




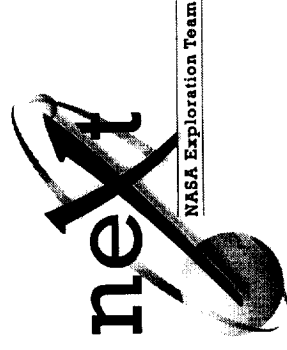
NASA Exploration Team (NExT) In-Space Transportation Overview

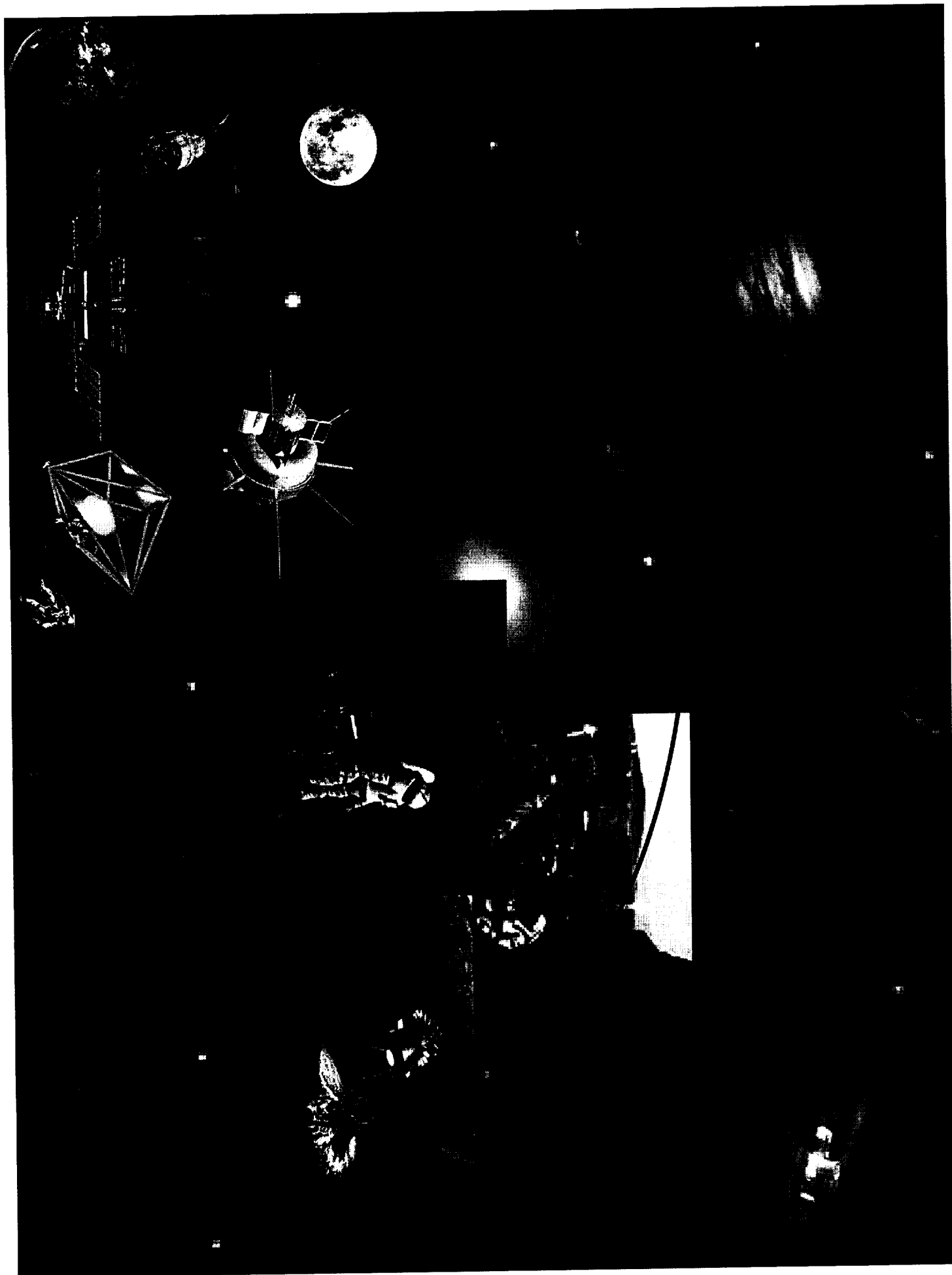


**51st JANNAF Propulsion Meeting
November 19, 2002
Lake Buena Vista, FL**

Bret G. Drake & Douglas R. Cooke
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, TX

Larry D. Kos
National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, AL



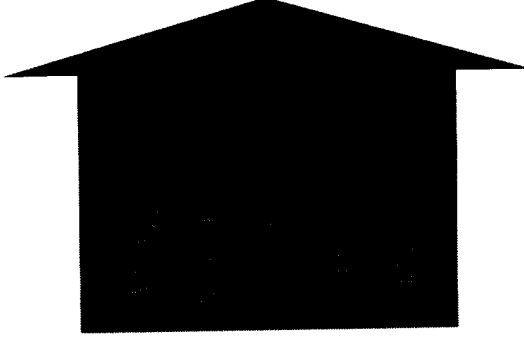




Enabling the Strategy

The Hurdles

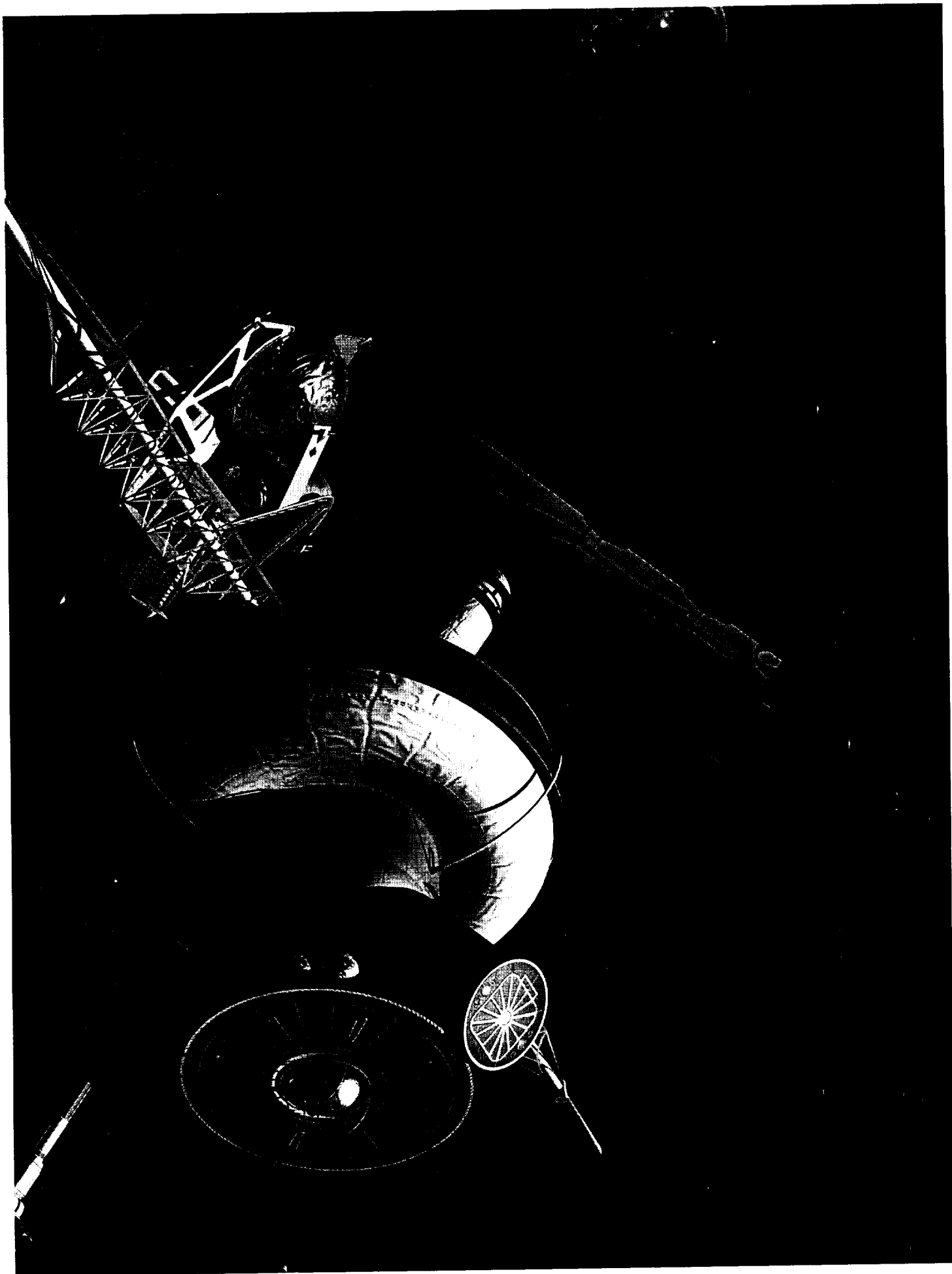
- **Space Transportation**
 - Safe, fast, and efficient
- **Affordable, Abundant Power**
 - Solar and nuclear
- **Crew Health and Safety**
 - Countermeasures and medical autonomy
- **Optimized Robotic and Human Operations**
 - Dramatically higher productivity; on-site intelligence
- **Space Systems Performance**
 - Advanced materials, low-mass, self-healing, self-assembly, self-sufficiency...

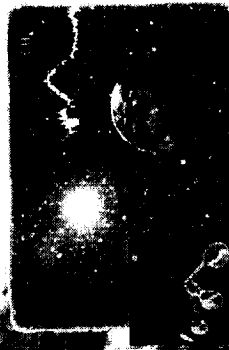


The Criteria

- **Compelling science objectives and benefits**
- **Knowledge about destinations**
- **Reliable and affordable mission concepts**
- **Acceptable technology readiness achieved**
- **Validation of capabilities for deep space missions**
- **Identified opportunities for partnership/leadership**
- **Inspiring and engaging to students and the public**







Human Mars Exploration

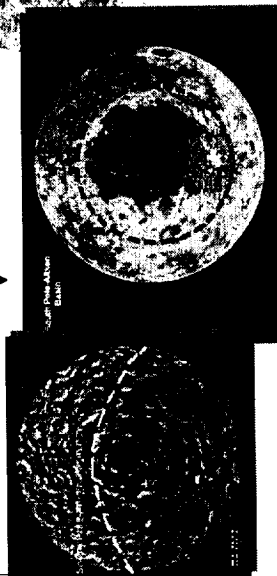
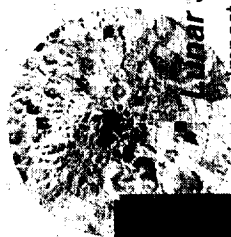
- Technology Development
- Deep-Space Operational Experience
- Mission Staging

Commercialization Opportunities

- Lunar Oxygen or Water Production
- Regolith Materials Processing
- Fuel Depot

Science

- Impact History in Near-Earth Space
- Composition of Lunar Mantle
- Past and Current Solar Activity
- Poles - History of Volatiles in Solar System



Construct, Deploy, and Service Advanced Astronomical Instruments

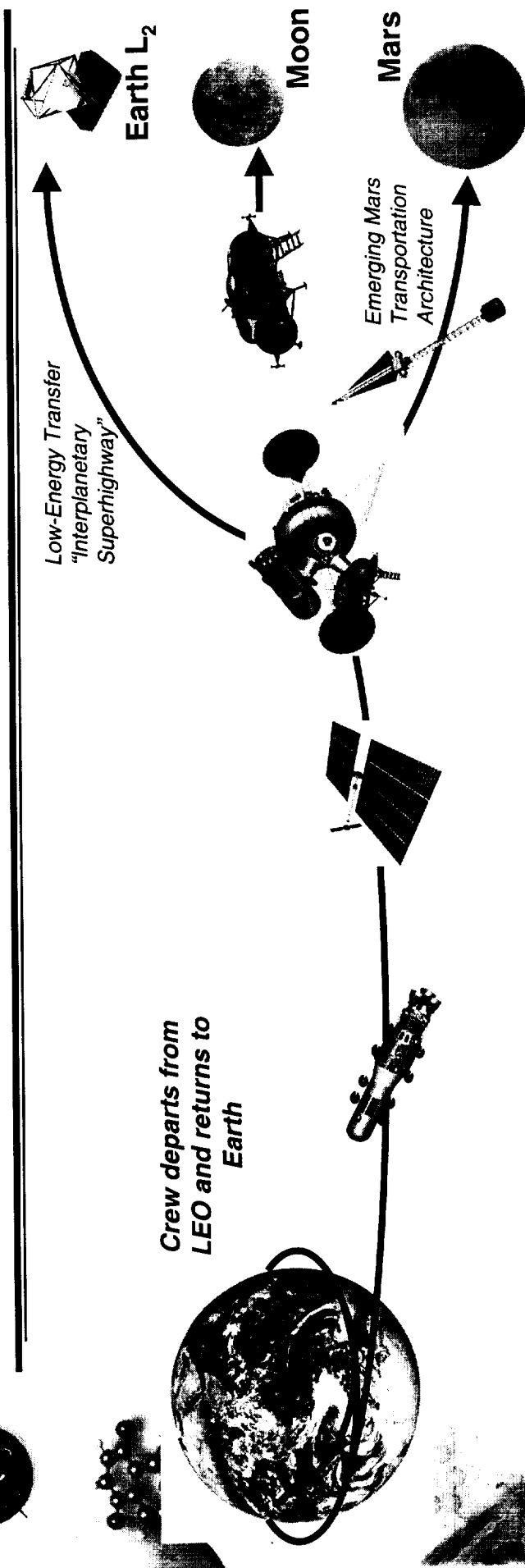
- Detect Biological Activity on Extra-Solar Planets
- Image Surfaces of Extra-Solar Planets
- Search for Location and Mechanism of Solar Flares
- Increase Lead Time and Accuracy for Geospace Forecasts



“Earth’s Neighborhood” Capabilities

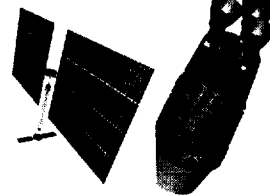


Earth's Neighborhood Architecture & Elements



Architecture

Elements



High-Energy Propulsion Stage

- High-efficiency stage used to deliver cargo from LEO to a final destination.



Earth-Moon L₁ Outpost

- "Gateway" to the Lunar surface
- Outpost for staging missions to Moon, Mars and telescope construction



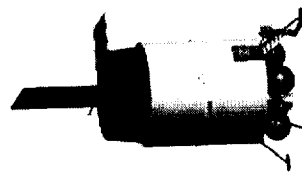
Lunar Transfer Vehicle

- Transports crew between LEO and Lunar L₁ (4-6 day trip)
- Nominal aerocapture+entry with contingency direct Earth return



Lunar Lander

- Transports crew between Outpost and Lunar Surface
- 9-day mission (3 days on Lunar surface)

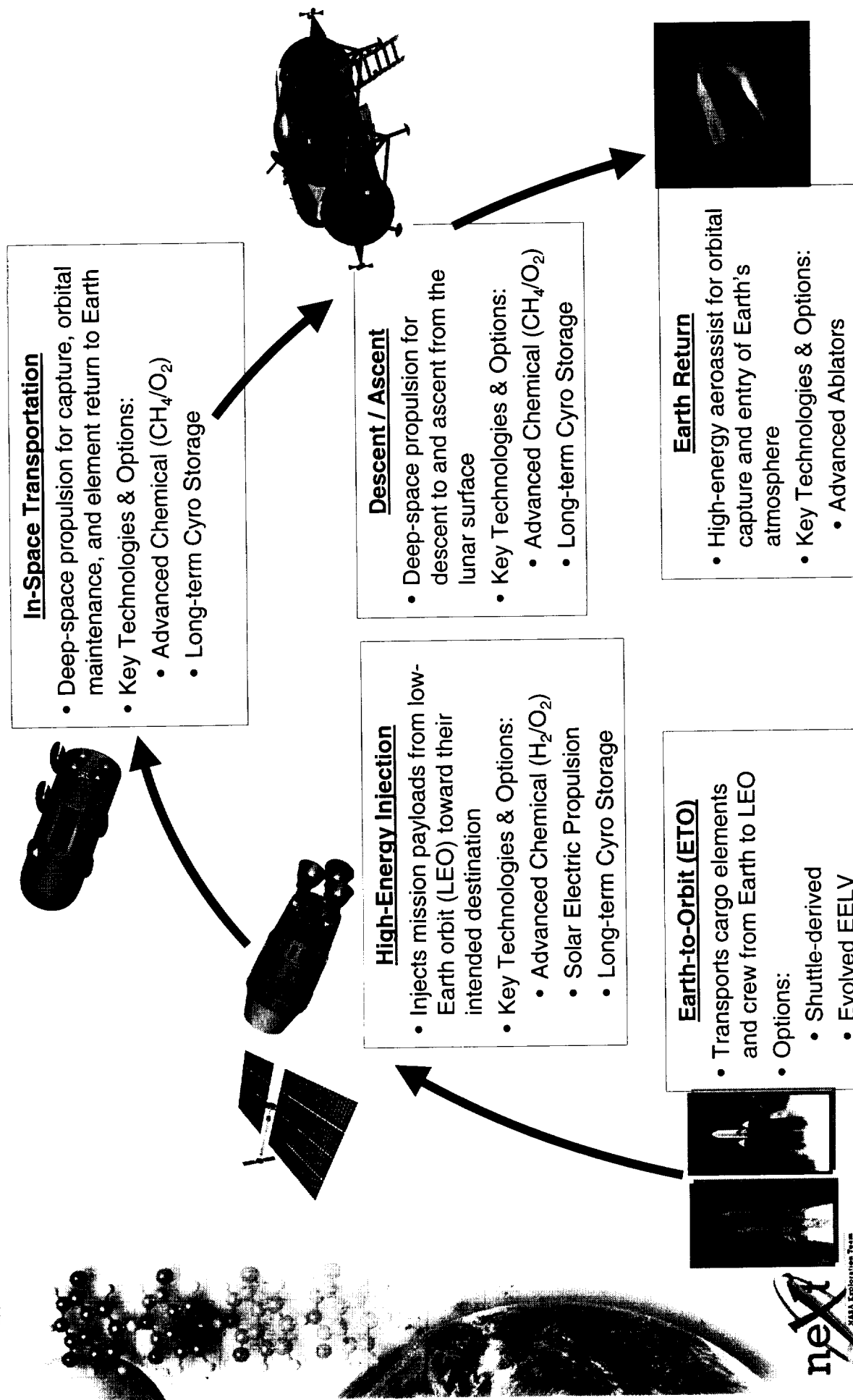


Lunar Habitat

- 30-day surface habitat placed at Lunar South Pole



Earth's Neighborhood Transportation Elements



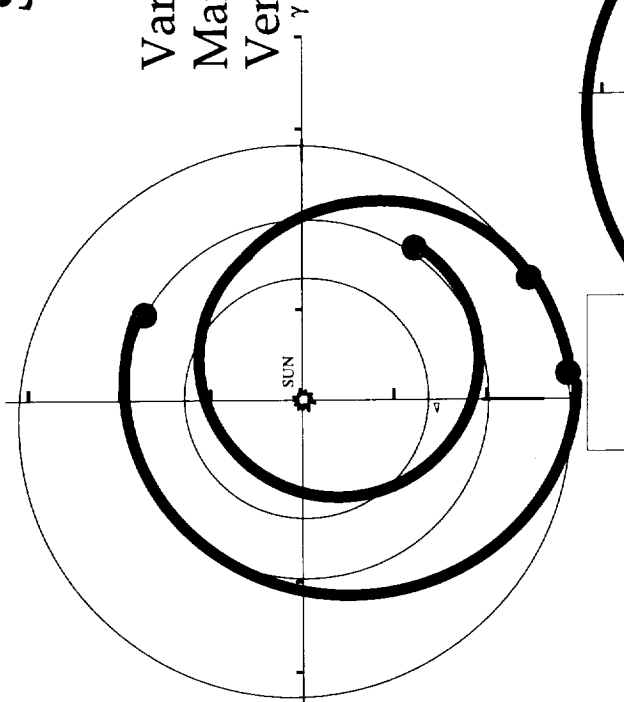




Mars Mission Trajectory Options

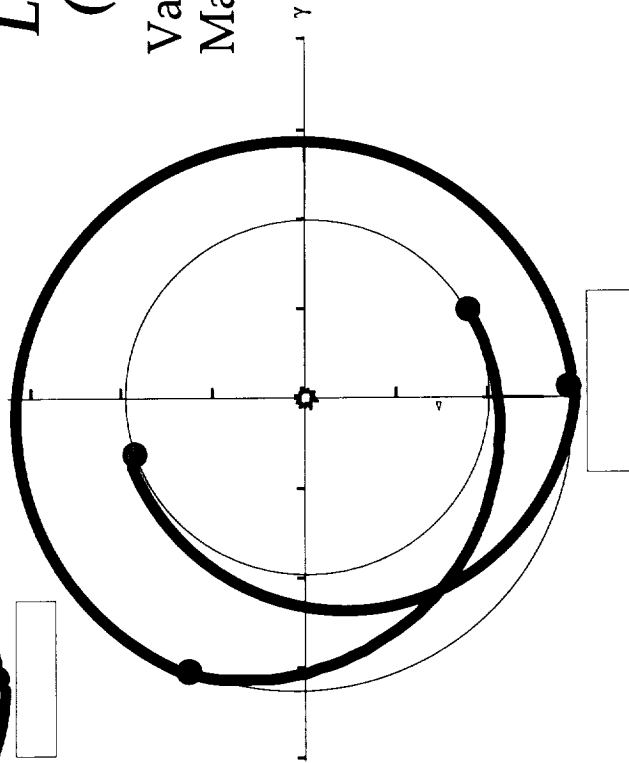
Short-Stay Missions (Opposition Class)

Variations of missions with short Mars surface stays and may include Venus swing-by



Long-Stay Missions (Conjunction Class)

Variations of missions with long Mars surface stays.

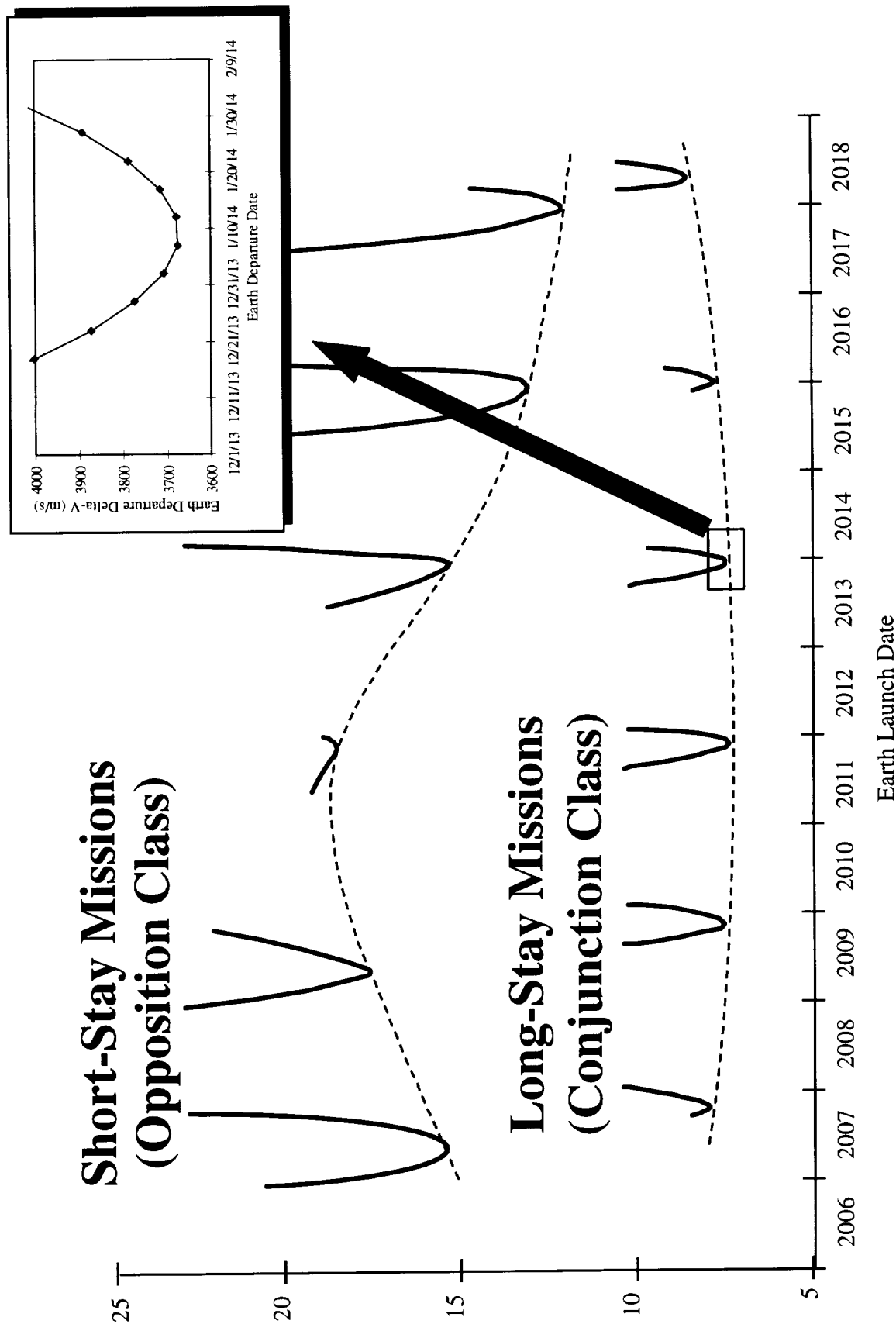


- Outbound
- Surface Stay
- Inbound





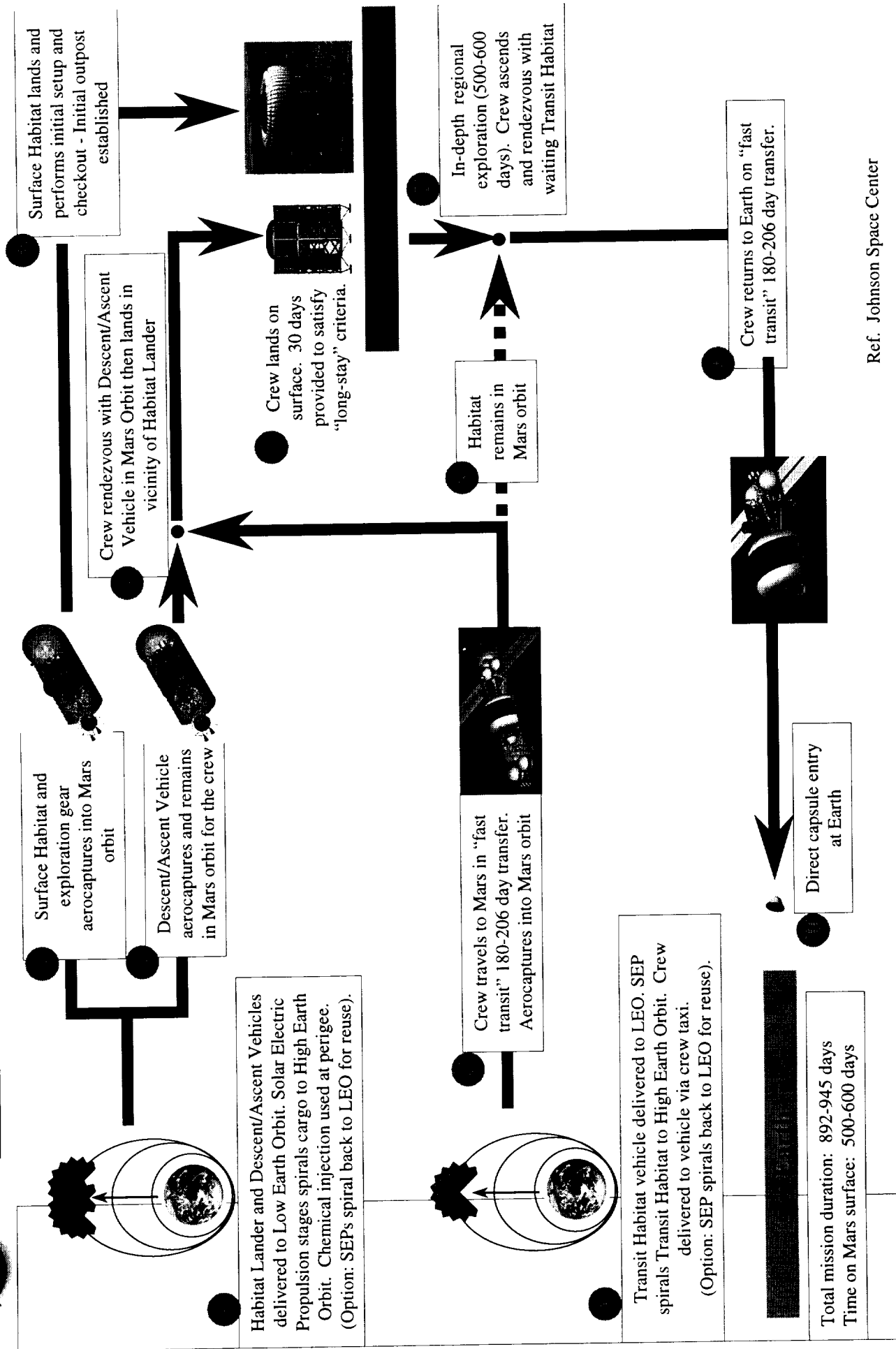
Delta-V Variations





Mars Long-Stay Mission Overview Option

(Solar Electric Propulsion Option)



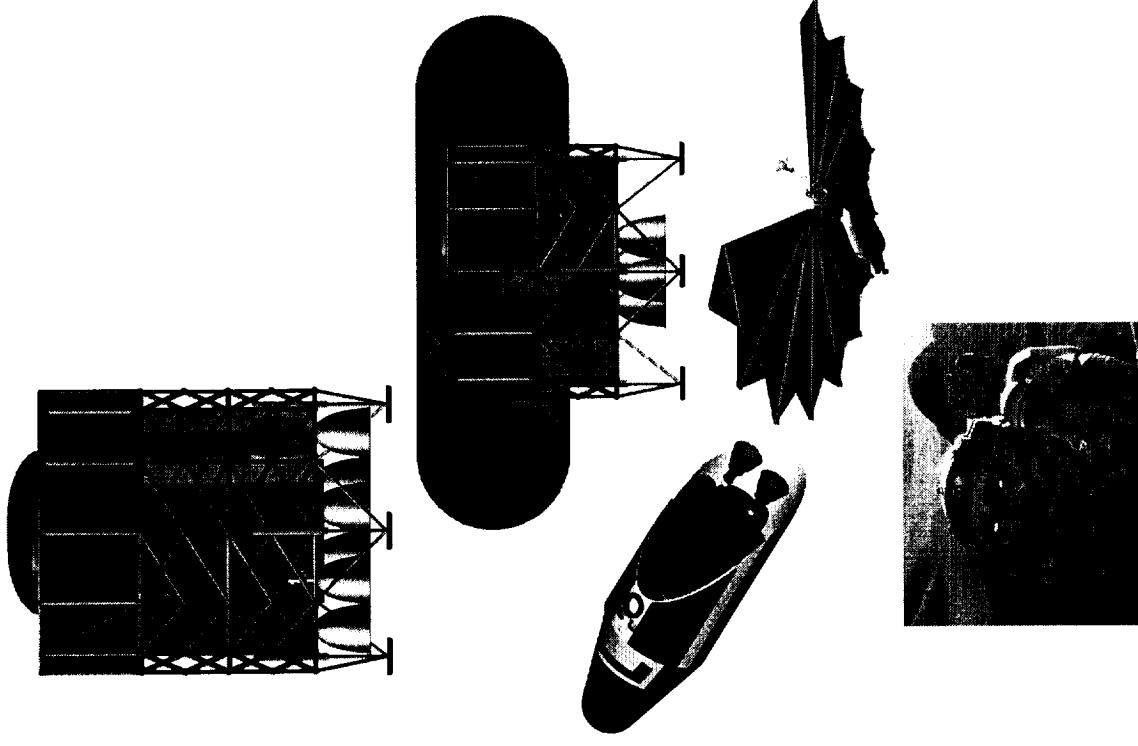


Mars Architecture



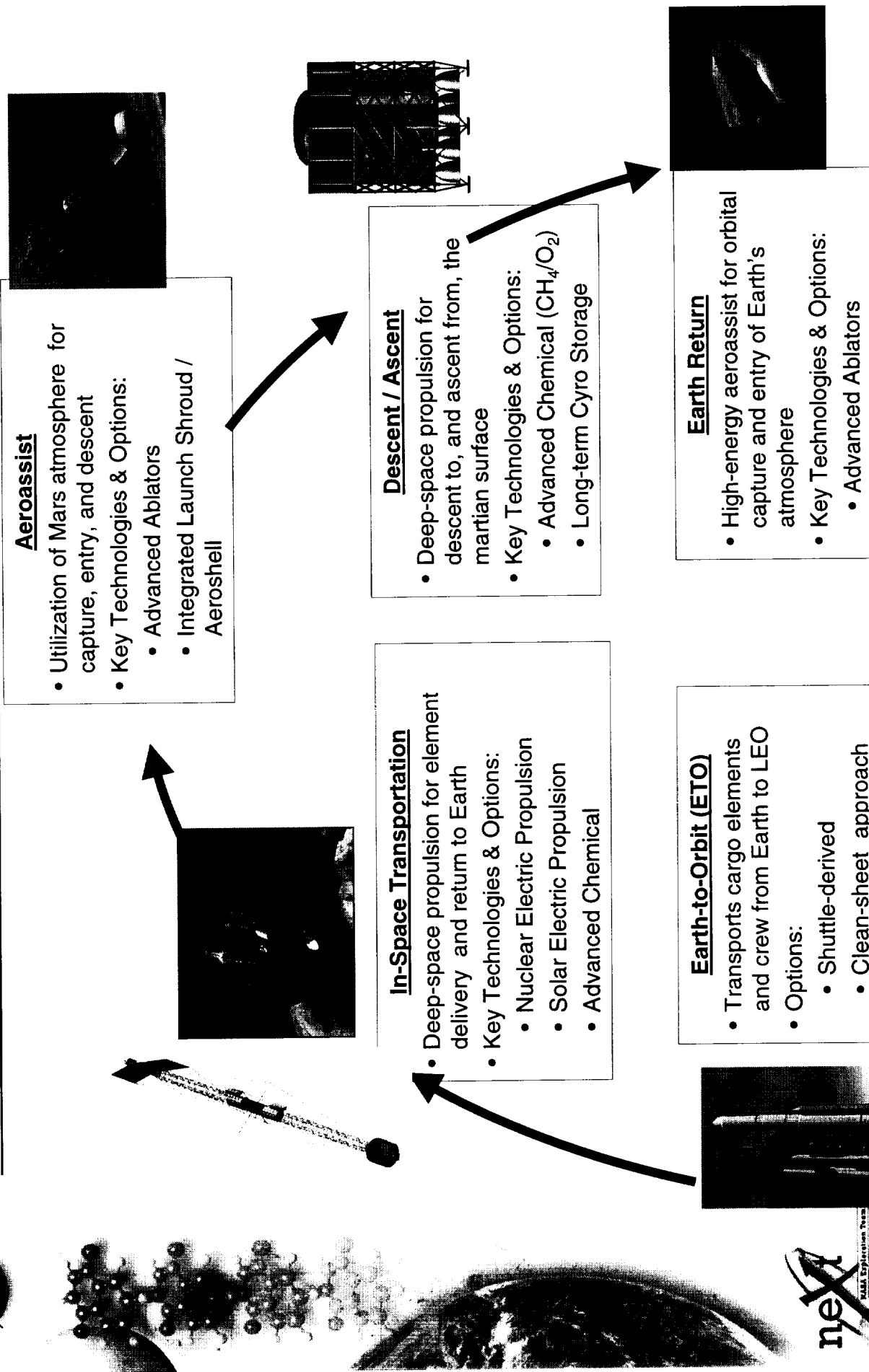
Key Attributes

- Crew of 4-6
- Short (30-day) initial visits for focused local science evolving to long (500-day) stays for extensive regional exploration
- Total mission durations range from 365 to 950 days.
- Capability to go to Mars any opportunity
- Maximum use of capabilities developed for Earth's Neighborhood
- Ability to introduce new technologies as they are developed
- Advanced transportation and enhanced launch capacity required to reduce risk and architecture cost



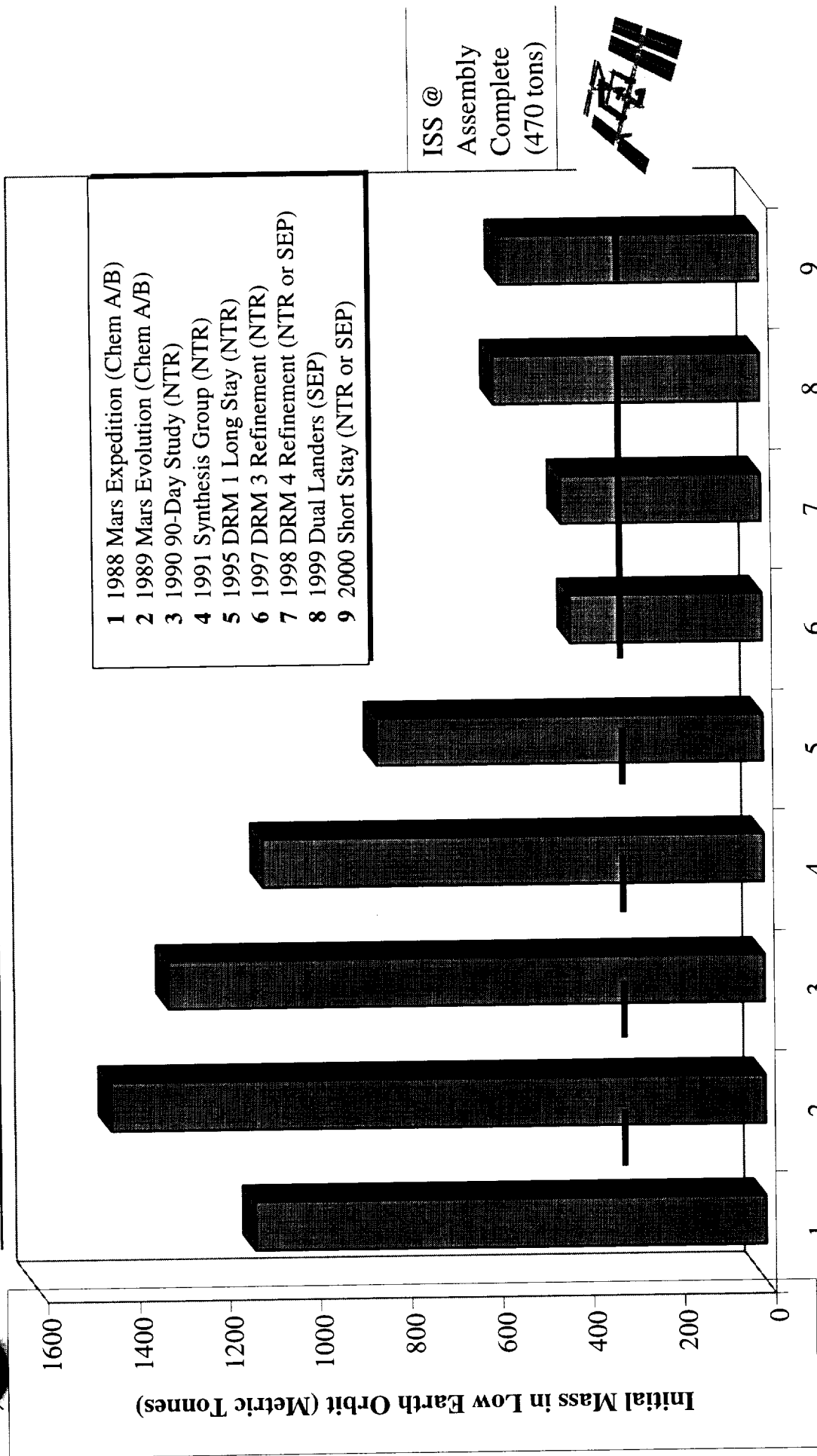


Mars Exploration Transportation Elements



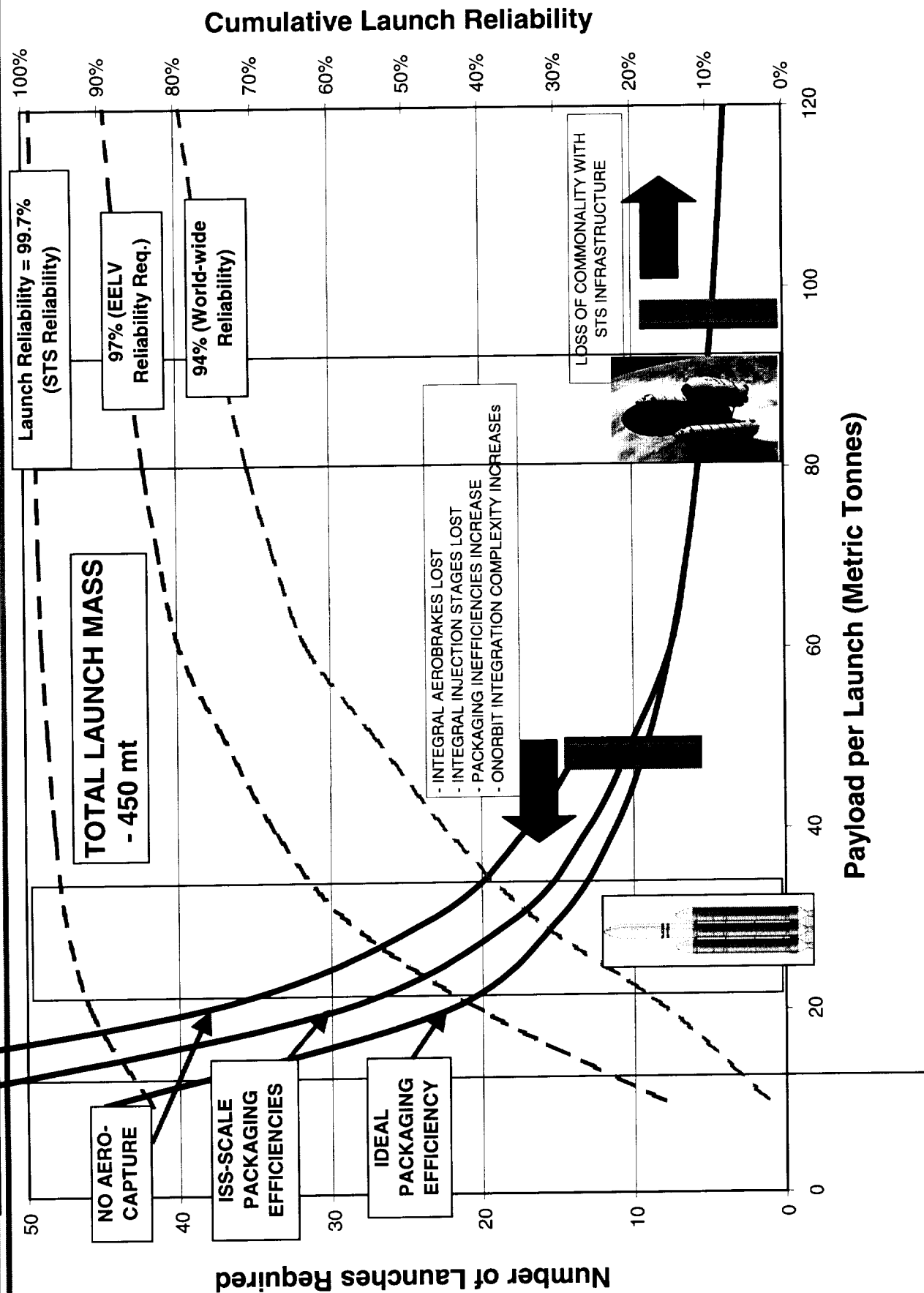


Mars Architecture Mass History





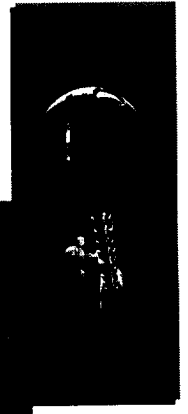
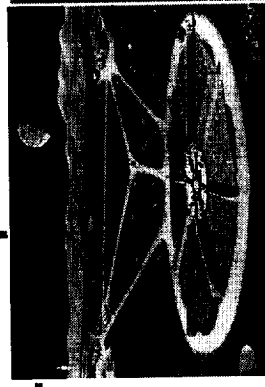
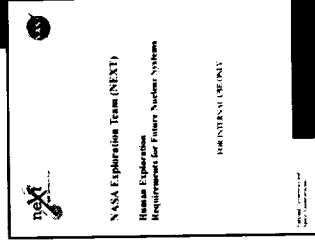
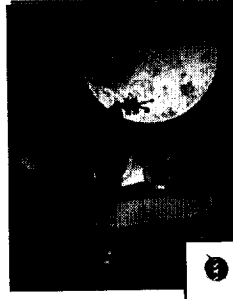
Mars Mission Launches Required and Associated Reliability





Nuclear Electric Propulsion Advantages

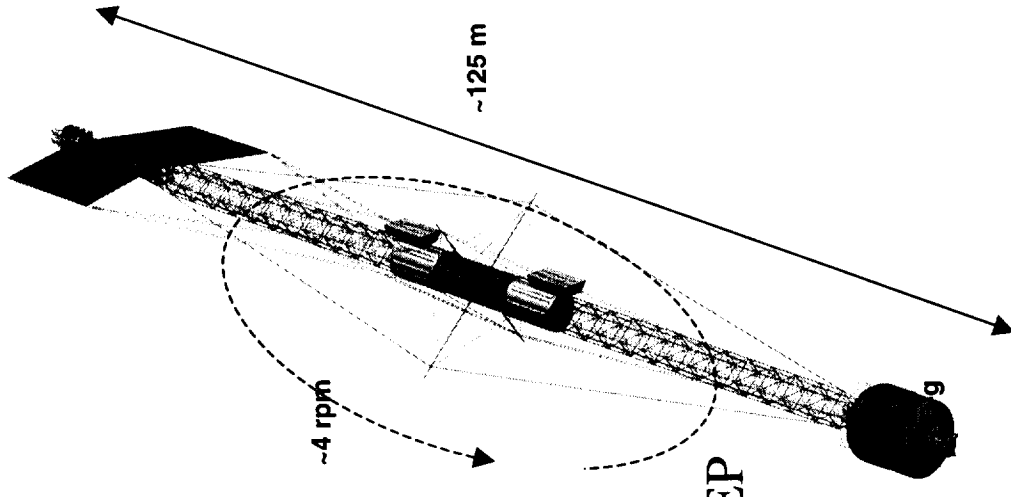
- **High propulsive performance**
 - Captures energetically challenging Mars missions in all opportunities (for ~ same prop mass)
- **High power availability**
 - Robust power for crew, spacecraft systems (<1% of propulsion requirements)
- **Potential technology convergence with advanced robotic exploration and NSI**
 - Reactor, power conversion, thrusters
 - Human exploration nuclear power requirements ready to submit to Nuclear Space Initiative
- **Potential convergence with technology development of surface nuclear power**
 - Moon - > 14 days (non-polar) at fixed location
 - Mars – “long” stay
- **Allows Sustainable, Evolvable Exploration Capability**
 - High reactor energy content and low prop mass fraction allows high degree of vehicle reusability for Mars missions
 - Evolution of power/propulsion possible to even more ambitious missions





Artificial Gravity (AG) Option

- Alternative to long-duration μ -g crew countermeasures
 - 1-g @ 4 rpm
- May simplify qualification of some spacecraft systems
 - Ameliorates extensive μ -g qualification
- Impacts currently under study
 - Vehicle design
 - Mass penalty
 - Mission capabilities
 - Operational considerations
 - No show-stoppers so far
- Good synergism between AG requirements and NEP vehicle characteristics
 - Booms/masts for rad exposure amelioration and AG moment arm
 - “Power module” as counterweight
- May greatly enhance short-stay missions
 - Crew readaptation time avoided





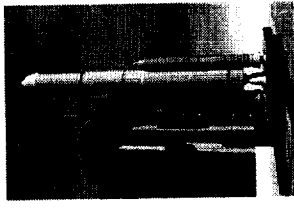
Key In-Space Transportation Technology Options & Needs

Earth-to-Orbit Launch

Application: Affordable delivery of cargo elements and crew from Earth to LEO.

Needs: 80-100 mt with payload volumes up to 10 m x 30 m.

Key Options: Shuttle derived or clean sheet approaches



Advanced Chemical Propulsion

Application: High energy injection stages for transportation of elements in near-Earth space. Advanced chemical engines for descent and ascent at planetary destinations.

Needs: 5-6 klbf throttleable engines which are compatible with utilization of local resources.

Key Options: O₂/Methane, O₂/Hydrogen

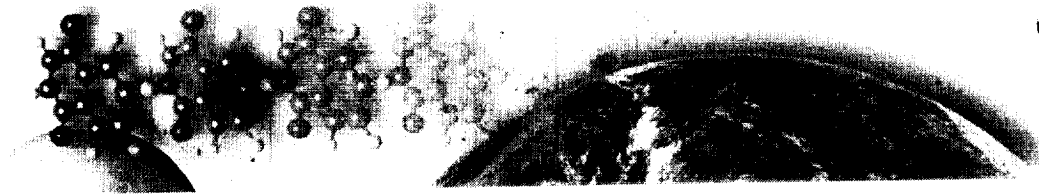
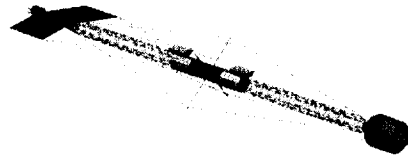


Electric Propulsion

Application: High-efficiency propulsion for delivery of cargo and crew elements from Earth vicinity to planetary destinations & return.

Key Options: 6-20 MWe nuclear electric.

1-3 MWe solar electric (combined with chemical injection stages and aeroassist at Mars).





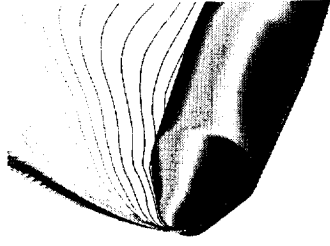
Key In-Space Transportation Technology Options & Needs

Aeroassist

Application: Utilization of planetary atmospheres (Mars and Earth return) for orbital capture, entry, descent, and landing.

Needs: Arrival speeds of 7.4 km/s (Mars) and 11.0 – 13.5 km/s (Earth return).

Key Options: Advanced ablators. Integrated aeroshell/payload shroud concepts.



Cryogenic Fluid Management

Application: Long-term storage of cryogenic fluids in space and on planetary surfaces.

Needs: Storage of cryogenic fluids (H_2 , O_2 , CH_4) for up to 1200 days.

Key Options: Combination of passive and active systems.

